

DESCRIPTION

[Title of Invention]

METHOD FOR MANUFACTURING GLASS SUBSTRATE FOR
5 INFORMATION RECORDING MEDIUM

[Technical Field]

[0001] The present invention relates to a method for manufacturing a glass
substrate for an information recording medium, particularly, to a method for
10 manufacturing a glass substrate for an information recording medium that is to
be mounted on an information recording device such as a hard disk drive (HDD)
as a part of an information recording medium.

[Background Art]

[0002] The variety of applied uses of an information recording device equipped
15 with an information recording medium such as a hard disk drive, and the
variety of appliances in which the information recording device can be used
have been growing every year. The demands for an increase in capacity, impact
resistance, and heat resistance of the information recording device tend to
increase every year. With this tendency, there are various requirements for a
20 glass substrate for an information recording medium (which may be simply
referred to as “glass substrate”) used for manufacturing the information
recording medium.

[0003] For example, as a result of an increase in capacity of the information
recording device (where a 2.5-inch recording medium, for example, has a
25 recording capacity of 500 GB (250 GB per side) and a surface recording density
of 600 Gbit/square inch or more), the bit area of the information recording
medium decreases. As a result, a slight defect that can occur in the glass
substrate causes a read error of the information recording medium. Examples
of the defect include projections, inclusions, and recessed crack defects (or pit
30 defects). Although the projections are comparatively easy to find by an

inspection or the like, the crack defects are difficult to find by an inspection.

[0004] In recent years, in order to deal with the crack defects, use of a diamond sheet has become mainstream in a grinding step (see JP 2009-99249A (Patent Literature 1)). The grinding step using the diamond sheet is advantageous for removing the crack defects. However, there is a problem of a high degree of difficulty in setting the conditions for grinding processing.

[0005] The method for manufacturing the glass substrate is roughly classified, for example, into a sheet process in which the glass substrate is manufactured from a sheet material, and a direct pressing process in which the glass substrate is manufactured by pressing molten glass into a disk shape using a molding machine or the like.

[0006] In the sheet process, when manufacturing the glass substrate from sheet glass called sheet material, the grinding step using the diamond sheet is performed after a surface roughening step.

[0007] On the other hand, although the direct pressing process requires the time for manufacturing the glass substrate by single wafer processing, it has been attracting attention again in recent years since the manufacturing of various glass compositions is possible. The glass substrate manufactured by the direct pressing process already has a rough surface, and thus the grinding step using the diamond sheet is performed without performing the surface roughening step.

[Citation List]

[Patent Literature]

[0008] [PLT 1]: JP 2009-99249A

[Summary of Invention]

[Technical Problem]

[0009] In the past few years, under the influence of an increase in density of the storage capacity of an information recording medium, it has also been necessary to perform the surface roughening step before the grinding step in a method for manufacturing a glass substrate for an information recording

medium that employs the direct pressing process. This is because a substrate having higher hardness is needed as the density of the storage capacity increases.

[0010] Specifically, if the glass substrate has low hardness, micro-scratches
5 occur on the glass substrate due to a trivial cause, resulting in defects.

Therefore, a glass substrate having high hardness is used. However, when the substrate having high hardness is subjected to the grinding step using a diamond sheet without performing the surface roughening step, an increase in pressure is required for grinding as compared to when the surface is roughened,
10 which causes new cracks on the surface of the glass substrate. Therefore, also when manufacturing the glass substrate using the direct pressing process, the surface roughening step is needed before the grinding step is performed.

[0011] Examples of the surface roughening step to be performed in the conventional float process include a frost step using a chemical solution and a
15 rough grinding step using a surface polishing machine with loose abrasive particles.

[0012] Although, as described above, it has been necessary to perform the surface roughening step before the grinding step is performed also when manufacturing the glass substrate using the direct pressing process, problems
20 described below occur if the aforementioned surface roughening step is applied to the direct pressing process as it is.

[0013] In the case where the frost step using a chemical solution is applied, the surface of the glass substrate is roughened by etching, the chemical solution enters scratches or cracks that are already present, and the scratches or cracks
25 are deepened, thereby leading to an increase in the amount of grinding and an increase in grinding time.

[0014] In the case where the rough grinding step using a surface polishing machine with loose abrasive particles is applied, new cracks occur in the glass substrate due to the pressure applied from the polishing machine.

30 [0015] The present invention was achieved in order to solve the problems

described above, and an object thereof is to provide a method for manufacturing a glass substrate for an information recording medium that can provide an appropriate surface roughening step before a grinding step, even in the case of using a glass substrate having high hardness.

5 [Solution to Problem]

[0016] A method for manufacturing a glass substrate for an information recording medium according to the present invention includes a first grinding step of grinding a main surface of a glass substrate obtained using a direct pressing process by spraying a plurality of particles onto the main surface of the
10 glass substrate through a nozzle, and a second grinding step of grinding the main surface of the glass substrate after the first grinding step with fixed abrasive particles mainly composed of diamond particles having an average particle size of 2 μm to 10 μm .

[0017] The first grinding step includes a step of grinding the main surface by spraying the particles onto the main surface such that the main surface has an
15 arithmetic average roughness Ra_1 maintained within the range of 1 μm to 5 μm and further an arithmetic average roughness Ra_2 , when a cut-off value is set to 2.5 μm to 80 μm , within the range of 0.1 μm to 1.0 μm .

[0018] In another embodiment, the main surface has a Vickers hardness of 610
20 kg/mm^2 or more.

In another embodiment, the particles have a maximum particle size of 50 μm to 150 μm .

[0019] In another embodiment, the particles are sprayed at a pressure of 0.1 MPa to 1 MPa.

25 [Advantageous Effects of the Invention]

[0020] The present invention can provide a method for manufacturing a glass substrate for an information recording medium that exhibits an appropriate surface roughening step before a grinding step, even in the case of using a substrate having high hardness.

30 [Brief Description of Drawings]

[0021] Fig. 1 is a perspective view showing an information recording device including a glass substrate manufactured using a method for manufacturing a glass substrate for an information recording medium according to an embodiment.

5 Fig. 2 is a plan view showing the glass substrate manufactured using the method for manufacturing a glass substrate for an information recording medium according to the embodiment.

 Fig. 3 is a cross sectional view taken along line III-III in Fig. 2, as seen in the direction of the arrows.

10 Fig. 4 is a plan view showing an information recording medium including a glass substrate manufactured by the method for manufacturing a glass substrate for an information recording medium according to the embodiment as an information recording medium.

 Fig. 5 is a cross sectional view taken along line V-V in Fig. 4, as seen in
15 the direction of the arrows.

 Fig. 6 is a flowchart showing the steps of the method for manufacturing a glass substrate for an information recording medium according to the embodiment.

 Fig. 7 is a schematic view showing a configuration of a blasting device to
20 be used in a blasting step performed on the glass substrate according to the embodiment.

 Fig. 8 is a schematic view showing an implementation status of the blasting step performed on the glass substrate according to the embodiment.

 Fig. 9 is a sectional view showing a double-side polishing machine to be
25 used in a rough polishing step of the method for manufacturing a glass substrate for an information recording medium according to the embodiment.

 Fig. 10 is a table showing the evaluation results of Examples 1 to 4 and Comparative Examples 1 and 2.

[Description of Embodiments]

30 [0022] Hereinafter, embodiments and examples based on the present invention

will be described with reference to the drawings. In cases where numbers, amounts, or the like are mentioned in the descriptions of the embodiments and the examples, the scope of the present invention is not necessarily limited to those numbers, amounts, or the like, unless otherwise specified. In the descriptions of the embodiments and the examples, identical or equivalent parts are denoted by identical reference numerals, and redundant description will not be repeated in some cases.

[0023] In the description, cracks are micro-scratches or recesses that exist in a surface of glass but are invisible to the human eye (or with an optical microscope). They are also called Griffith flaws.

[0024] Glass breakage occurs, when tensile stress is applied to a surface of glass, due to the stress concentrating on the bases of the cracks and thereby allowing the cracks to enlarge. The size of the cracks ranges from several tens of nm to as large as several tens of μm . Cracks naturally occur in the course of dealing with glass, and cracks already exist in glass blanks.

[0025] Once such cracks are formed deeply in glass, it is difficult to completely remove the cracks, even if the surface is ground later by a polishing step or the like, since the cracks enlarge (grow), for example, due to pressure applied during polishing. Therefore, it is important to suppress the occurrence of new cracks while removing existing cracks in a grinding step.

[0026] Information recording device 30

First, an information recording device 30 will be described with reference to Fig. 1. Fig. 1 is a perspective view showing the information recording device 30. The information recording device 30 includes, as an information recording medium 10, a glass substrate 1 manufactured by a method for manufacturing a glass substrate for an information recording medium (hereinafter, referred to as simply “glass substrate”) according to an embodiment.

[0027] Specifically, the information recording device 30 includes the information recording medium 10, a housing 20, a head slider 21, a suspension

22, an arm 23, a vertical shaft 24, a voice coil 25, a voice coil motor 26, a clamping member 27, and a fixing screw 28. On the upper surface of the housing 20, a spindle motor (not shown) is provided.

[0028] The information recording medium 10 such as a magnetic disk is

5 rotatably fixed to the aforementioned spindle motor by the clamping member 27 and the fixing screw 28. The information recording medium 10 is driven to rotate by the spindle motor at a rotation speed of several thousand rpm, for example. As described below in detail with reference to Fig. 4 and Fig. 5, the information recording medium 10 is manufactured by forming a compressive
10 stress layer 12 (see Fig. 5) and a magnetic recording layer 14 (see Fig. 4 and Fig. 5) on the glass substrate 1.

[0029] The arm 23 is attached pivotably about the vertical shaft 24. The suspension 22 in the form of a leaf spring (cantilever beam) is attached to the tip of the arm 23. The head slider 21 is attached to the tip of the suspension 22 so
15 as to sandwich the information recording medium 10 with another head slider.

[0030] The voice coil 25 is attached to the arm 23 on the opposite side of the head slider 21. The voice coil 25 is sandwiched and held between magnets (not shown) provided on the housing 20. The voice coil 25 and the magnets
constitute the voice coil motor 26.

20 [0031] A predetermined current is supplied to the voice coil 25. The arm 23 pivots about the vertical shaft 24 due to the effect of the electromagnetic force generated by the current flowing through the voice coil 25 and the magnetic field of the aforementioned magnets. The pivoting of the arm 23 causes the suspension 22 and the head slider 21 to pivot in a direction of the arrow AR1.

25 The head slider 21 moves back and forth in the radial direction of the information recording medium 10 on the front surface and the back surface of the information recording medium 10. A magnetic head (not shown) provided in the head slider 21 performs a seek operation.

[0032] While the seek operation is performed, the head slider 21 is subjected to
30 a buoyant force due to the airflow generated with the rotation of the information

recording medium 10. The head slider 21 travels at a constant floating height with respect to a surface of the information recording medium 10 due to the balance between the buoyant force and the elastic force (pressing force) of the suspension 22. By traveling, the magnetic head provided in the head slider 21 can perform recording and reproduction of information (data) with respect to a predetermined track in the information recording medium 10. The information recording device 30 on which the glass substrate 1 is mounted as one of members constituting the information recording medium 10 is configured as described above.

10 [0033] Glass substrate 1

Fig. 2 is a plan view showing the glass substrate 1 manufactured using the method for manufacturing a glass substrate for an information recording medium based on the present embodiment. Fig. 3 is a cross sectional view taken along line III-III in Fig. 2, as seen in the direction of the arrows.

15 [0034] As shown in Fig. 2 and Fig. 3, the glass substrate 1 (glass substrate for an information recording medium) used for the information recording medium 10 (see Fig. 4 and Fig. 5) as its part has a main surface 2, a main surface 3, an inner circumferential edge surface 4, a hole 5, and an outer circumferential edge surface 6, and is formed into a disk shape as a whole. The hole 5 is provided so as to pass through from the main surface 2 on one side to the main surface 3 on the other side. Chamfered portions 7 are formed between the main surface 2 and the inner circumferential edge surface 4 and between the main surface 3 and the inner circumferential edge surface 4. Chamfered portions 8 are formed between the main surface 2 and the outer circumferential edge surface 6 and between the main surface 3 and the outer circumferential edge surface 6.

25 [0035] The glass substrate 1 has a size of 0.8 inch, 1.0 inch, 1.8 inches, 2.5 inches, or 3.5 inches, for example. The glass substrate has a thickness of 0.30 mm to 2.2 mm, for example, from the viewpoint of preventing damage. The dimensions of the glass substrate in this embodiment are as follows: the outer diameter is about 64 mm, the internal diameter is about 20 mm, and the

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thickness is about 0.8 mm. The thickness of the glass substrate is a value calculated from an average of values measured at multiple arbitrary points that are point-symmetrical on the glass substrate 1. From the viewpoint of increasing the hardness of the glass substrate, it is preferable that the Vickers hardness of the glass substrate 1 is 610 kg/mm² or more.

[0036] Information recording medium 10

Fig. 4 is a plan view showing the information recording medium 10 including the glass substrate 1 as an information recording medium. Fig. 5 is a cross sectional view taken along line V-V in Fig. 4, as seen in the direction of the arrows.

[0037] As shown in Fig. 4 and Fig. 5, the information recording medium 10 includes the glass substrate 1, the compressive stress layer 12, and the magnetic recording layer 14. The compressive stress layer 12 is formed to cover the main surfaces 2 and 3, the inner circumferential edge surface 4, and the outer circumferential edge surface 6 of the glass substrate 1. The magnetic recording layer 14 is formed to cover a predetermined region on the main surfaces 2 and 3 of the compressive stress layer 12. The compressive stress layer 12 is formed on the inner circumferential edge surface 4 of the glass substrate 1, thereby forming a hole 15 inside the inner circumferential edge surface 4. The information recording medium 10 is fixed to the spindle motor provided on the housing 20 (see Fig. 1), using the hole 15.

[0038] In the information recording medium 10 shown in Fig. 5, the magnetic recording layers 14 are formed on both of the compressive stress layer 12 formed on the main surface 2 and the compressive stress layer 12 formed on the main surface 3 (both sides). The magnetic recording layer 14 may be provided only on the compressive stress layer 12 formed on the main surface 2 (one side), or may be provided only on the compressive stress layer 12 formed on the main surface 3 (one side).

[0039] The magnetic recording layer 14 is formed by spin coating the compressive stress layers 12 on the main surfaces 2 and 3 of the glass substrate

1 with a thermosetting resin in which magnetic particles are dispersed (spin coating process). The magnetic recording layer 14 may also be formed by sputtering, electroless plating, or the like performed onto the compressive stress layers 12 on the main surfaces 2 and 3 of the glass substrate 1.

5 [0040] The film thickness of the magnetic recording layer 14 is about 0.3 μm to 1.2 μm in the case of spin coating, is about 0.04 μm to 0.08 μm in the case of sputtering, and is about 0.05 μm to 0.1 μm in the case of electroless plating. From the viewpoint of making the film thinner and denser, it is preferable to form the magnetic recording layer 14 by sputtering or electroless plating.

10 [0041] As a magnetic material used for the magnetic recording layer 14, in order to provide high adhesion strength, it is preferable to use a Co-based alloy that contains Co, which has high crystal anisotropy, as a main component and to which Ni and Cr are added to adjust the residual magnetic flux density, and the like.

15 [0042] In order to allow the magnetic head to slide smoothly, a surface of the magnetic recording layer 14 may be thinly coated with a lubricant. One example of the lubricant is a lubricant obtained by diluting perfluoropolyether (PFPE), which is a liquid lubricant, with a Freon-based solvent or the like.

[0043] The magnetic recording layer 14 may be provided with a base layer or a
20 protective layer, as needed. The base layer of the information recording medium 10 is selected depending on the type of the magnetic film. For example, at least one selected from non-magnetic metals such as Cr, Mo, Ta, Ti, W, V, B, Al, and Ni can be used as a material for the base layer.

[0044] The base layer provided in the magnetic recording layer 14 is not limited
25 to a single layer, and may have a multilayer structure in which layers of the same type or different types are stacked. For example, a multilayer base layer such as Cr/Cr, Cr/CrMo, Cr/CrV, NiAl/Cr, NiAl/CrMo, or NiAl/CrV may be provided.

[0045] Examples of the protective layer that prevents wear and corrosion of the
30 magnetic recording layer 14 include a Cr layer, a Cr alloy layer, a carbon layer, a

hydrogenated carbon layer, a zirconia layer, and a silica layer. Such a protective layer can be continuously formed by an in-line sputtering apparatus together with the base layer, the magnetic film, or the like. The protective layer may be a single layer, or may have a multilayer structure composed of
 5 layers of the same type or different types.

[0046] Another protective layer may be formed on the aforementioned protective layer or instead of the aforementioned protective layer. For example, instead of the aforementioned protective layer, a silicon oxide (SiO_2) layer may be formed by applying, onto the Cr layer, a solution obtained by diluting
 10 tetraalkoxysilane with an alcohol-based solvent and dispersing colloidal silica fine particles therein, and by further calcining it.

[0047] Method for manufacturing glass substrate

Next, a method S100 for manufacturing a glass substrate (glass substrate for an information recording medium) according to this embodiment
 15 will be described with reference to a flowchart shown in Fig. 6. The method S100 for manufacturing a glass substrate according to this embodiment includes a plate glass molding step S10, a cutting molding step S20, a blasting step S30, a lapping step S40, an edge surface polishing step S50, a rough polishing step S60, a washing step S65, a chemical strengthening step S70, a precision
 20 polishing step S80, and a scrubbing step S90.

[0048] The glass substrate obtained through the scrubbing step S90 is subjected to a magnetic thin film forming step S200. The information recording medium 10 (see Fig. 4 and Fig. 5) is obtained through the magnetic thin film forming step S200. Hereinafter, steps S10 to S90 constituting the
 25 manufacturing method S100 for manufacturing a glass substrate will be sequentially described in detail.

[0049] Plate glass molding step S10

First, a plate glass is manufactured in the plate glass molding step S10, using molten glass as a material, by a known forming method such as a direct
 30 pressing process, a float process, a down drawing process, a redrawing process,

or a fusion process. Among these, the direct pressing process can form a target molding of glass directly from fused glass, and therefore is preferable for mass production of plate glass having the same shape. In the direct pressing process, molten glass is supplied to a press mold, and the glass in the softened state is pressed by the press mold so that plate glass is molded.

[0050] As a material of the glass substrate, amorphous glass and crystallized glass, for example, can be used. When amorphous glass is used, a glass substrate for an information recording medium that can be chemically strengthened suitably and is excellent in flatness of the main surface and strength of the substrate can be provided.

[0051] Cutting molding step S20

In the cutting molding step S20, an internal hole is formed at the center of the glass substrate, using a cylindrical diamond drill, thereby forming the glass substrate having an annular shape (coring processing). Thereafter, the inner circumferential edge surface and the outer circumferential edge surface are ground by a diamond grindstone, so as to be chamfered in a predetermined manner (forming and chamfering).

[0052] Blasting step S30

In the blasting step S30, the main surfaces 2 and 3 of the glass substrate 1 formed through the aforementioned steps S10 and S20 are ground by spraying a plurality of particles (abrasive particles) 200g onto the main surfaces 2 and 3 of the glass substrate 1 (first grinding step).

[0053] With reference to Fig. 7 and Fig. 8, the blasting step S30 will be described. Fig. 7 is a schematic view showing a configuration of a blasting device 100 used in the blasting step performed on the glass substrate 1, and Fig. 8 is a schematic view showing an implementation status of the blasting step performed on the glass substrate 1.

[0054] In Fig. 7, the main surfaces 2 and 3 of the glass substrate 1 are blasted using the blasting device 100. The blasting device 100 includes a support base 120 that supports the glass substrate 1 and a nozzle 110 that sprays the

particles (abrasive particles) 200g onto a main surface of the glass substrate 1 supported by the support base 120. The blasting device 100 blasts the entire main surfaces 2 and 3 of the glass substrate 1 substantially uniformly by moving the support base 120 or the nozzle 110. After finishing blasting the main surface 2, the glass substrate 1 is moved and the blasting device 100 blasts the main surface 3.

[0055] An ejection hole is formed at the tip of the nozzle 110, and the particles (abrasive particles) 200g are ejected through the ejection hole. The particles (abrasive particles) 200g ejected through the nozzle 110 are sprayed onto the glass substrate 1 while spreading within the range of a spray opening angle A° , with the center line CL serving as the center. When blasting the glass substrate 1, the nozzle 110 is arranged so that the center line CL is substantially perpendicular to the main surfaces 2 and 3.

[0056] Fig. 8 is a schematic plan view showing the glass substrate (glass substrate precursor) 1 before being blasted by the blasting device 100. The referential sign R30 in Fig. 8 indicates a region (blast area) to be blasted (polished) with the particles (abrasive particles) 200g ejected through the nozzle 110.

[0057] As shown in Fig. 8, the nozzle 110 moves over a surface of the glass substrate 1, for example, in a zigzag scanning pattern (line P in the figure). This allows the entire surface of the glass substrate 1 to be blasted with the particles (abrasive particles) 200g ejected through the nozzle 110. The glass substrate 1 may be moved while the nozzle 110 is fixed.

[0058] The size of the particles (abrasive particles) 200g affects the grinding speed and the efficiency of the grinding amount. When the size of the particles (abrasive particles) 200g is excessively large, the glass substrate 1 is damaged, and when the size is excessively small, the glass substrate 1 cannot be ground. Examples of the particles (abrasive particles) 200g to be used include particles having sufficient hardness such as alumina particles, ceramic particles, and SiC. The particles (abrasive particles) 200g having a maximum particle size of 50 μm

to 150 μm are used.

[0059] When the particles (abrasive particles) 200g are sprayed at low pressure, the glass substrate 1 cannot be ground. When the spraying pressure is excessively high, the glass substrate 1 may crack in some cases. The allowance (grinding thickness) of the glass substrate 1 is correlated with the size of the particles (abrasive particles) 200g. When the size of the particles (abrasive particles) 200g is large, a comparatively large amount of grinding is needed. This is because cracks occur due to the particle size at the beginning of grinding. The spraying pressure of the particles (abrasive particles) 200g is preferably 0.1 MPa to 1 MPa.

[0060] For grinding in the blasting step S30, the plurality of particles (abrasive particles) 200g dispersed in water may be sprayed onto the glass substrate 1. When the spraying is performed in the state where the particles 200g are dispersed in water, effects in which glass waste generated during grinding can be simultaneously removed, for example, is obtained. The glass substrate 1 whose main surfaces have a predetermined roughness is obtained by the blasting step S30.

[0061] In the blasting step S30 according to this embodiment, the main surfaces 2 and 3 are ground by spraying the particles 200g onto the main surfaces 2 and 3 such that the main surfaces 2 and 3 have an arithmetic average roughness Ra_1 maintained within the range of 1 μm to 5 μm and further an arithmetic average roughness Ra_2 , when a cut-off value is set to 2.5 μm to 80 μm , within the range of 0.1 μm to 1.0 μm .

[0062] The arithmetic average roughness Ra_1 herein is an arithmetic average roughness measured based on "JIS B0601: 2001" and "JIS B0633: 2001" of Japanese Industrial Standards. The "JIS B0601: 2001" is in conformity with ISO 4287: 1997, and the "JIS B0633: 2001" is in conformity with ISO 4288: 1996.

[0063] Being different from the arithmetic average roughness Ra_1 , the arithmetic average roughness Ra_2 means an arithmetic average roughness

determined from a roughness curve when a cut-off value (wavelength) is set to an arbitrary range.

[0064] A contact roughness measuring instrument, SURFCOM 1400D, manufactured by MITUTOYO CORPORATION is used for measuring the

5 roughness of the main surfaces 2 and 3 of the glass substrate 1. The measurement is performed based on Japanese Industrial Standards mentioned above.

[0065] In the roughness measurement, a low frequency cut-off depends on the shape of the tip of a contact stylus. The tip shape currently used is $\theta = 60^\circ$ and
10 $r_{tip} = 2 \mu\text{m}$, and the low frequency cut-off (λ_s) is set to $2.5 \mu\text{m}$.

[0066] The measurement of the arithmetic average roughness Ra_1 is performed in accordance with Japanese Industrial Standards mentioned above, and the high frequency cut-off (λ_c) is set to an appropriate value depending on the shape to be measured. When Ra is $0.1 \mu\text{m}$ to $10 \mu\text{m}$, the high frequency cut-off is set
15 to 0.25 mm or 0.8 mm . The evaluation length is set to 5 times the length of λ_c .

[0067] In the case where λ_c is forcibly set, the measurement is not in accordance with the aforementioned standards of JIS. In this embodiment, λ_c is forcibly set because this embodiment is based on the finding that grinding with fixed abrasive particles can be smoothly performed by a change (increase)
20 in roughness components in a wavelength region that is significantly shorter than a general cut-off value.

[0068] The roughness curve is determined with a high frequency cut-off (λ_c) of $80 \mu\text{m}$. The measurement length is set to 5 times the length of λ_c , in the same manner as the evaluation length.

25 [0069] The roughness is defined based on JIS B00601: 2001 (in conformity with ISO 4287: 1996).

[0070] The "arithmetic average roughness" indicates an average amplitude parameter in the height direction, the "roughness curve" indicates a band pass filter having a cut-off value of $\lambda_s - \lambda_c$, and the "filter" indicates a phase
30 compensation filter in which a wavelength at which the attenuation rate is 50%

serves as a cut-off value.

[0071] Further, for determining the roughness, a measured profile curve is first obtained by a measuring instrument. Next, a profile curve is obtained from the measured profile curve by passing it through a low-pass filter (λ_S). Further, the
 5 profile curve is passed through a high-pass filter (λ_C), so that the "roughness curve" is obtained.

[0072] An average of absolute values of height of the respective points from the average value of the "roughness curve" serves as an arithmetic average roughness. The "roughness curve" is obtained by varying the value λ_C of Ra_1 in
 10 accordance with JISB0633: 01. The "roughness curve" is obtained by setting λ_C of Ra_2 to 80 μm .

[0073] Lapping step S40

In the lapping step S40, the main surfaces 2 and 3 of the glass substrate 1 is processed using diamond, as abrasive particles, which is formed into a sheet
 15 shape using a resin or the like (second grinding step).

[0074] The particle size of diamond can be appropriately changed depending on the purpose, but the average particle size is preferably 2 μm to 10 μm . When the particle size of diamond is less than 2 μm , processing does not proceed, resulting in a failure to remove cracks that have occurred in the main surfaces 2
 20 and 3 of the glass substrate 1. Conversely, when the particle size of diamond exceeds 10 μm , cracks occur in the main surfaces 2 and 3 of the glass substrate 1 due to the diamond.

[0075] With the densification in recent years, the particle size of diamond is being reduced. However, due to the need for the balance with processability,
 25 the particle size of diamond is more preferably 2 μm to 4 μm . In the grinding step, the main surfaces 2 and 3 of the glass substrate 1 are ground by about 50 μm to 250 μm .

[0076] Edge surface polishing step S50

In the edge surface polishing step S50, the inner circumferential edge
 30 surface and the outer circumferential edge surface of the glass substrate 1 are

polished using a polishing brush having spiral brush hairs. While a polishing slurry is supplied between the polishing brush and each edge surface of the glass substrate 1, the polishing brush abutting against the edge surface is rotated. The polishing brush abutting against the edge surface may be rotated in the state where the glass substrate 1 is immersed in a polishing liquid.

[0077] Rough polishing step S60

After the inner circumferential edge surface and the outer circumferential edge surface of the glass substrate 1 are polished, the main surfaces 2 and 3 are roughly polished multiple separate times. For example, the main surfaces 2 and 3 are polished two separate times in the first and the second rough polishing steps. The finishing accuracy of the glass substrate 1 is gradually increased, thereby allowing the glass substrate 1 having a highly smooth and flat surface to be obtained. In the case where the rough polishing is performed two separate times, the first rough polishing step mainly aims to remove scratches and distortion remaining on the main surfaces 2 and 3 in the aforementioned lapping step, and the second rough polishing step aims to finish the main surfaces 2 and 3 to mirror surfaces.

[0078] The rough polishing step S60 is a step of roughly polishing the main surfaces 2 and 3 of the glass substrate 1 using a polishing slurry such that the surface roughness of the glass substrate 1 that is finally required in the subsequent precision polishing step S80 is efficiently obtained. The polishing method employed in this step is not particularly limited, and polishing can be performed using a double-side polishing machine.

[0079] In this embodiment, a double-side polishing machine 40 shown in Fig. 9 is used. The double-side polishing machine 40 includes a lower surface plate 41 and an upper surface plate 42 that are vertically opposed to each other. To the opposing surfaces of the lower surface plate 41 and the upper surface plate 42, polishing pads 43 and 44 are respectively fixed.

[0080] The glass substrate 1 is held by a holding hole of a carrier 45, and is sandwiched between the lower surface plate 41 and the upper surface plate 42.

The lower surface plate 41 and the upper surface plate 42 are rotated by a driving source (not shown). The rotational driving of the lower surface plate 41 and the upper surface plate 42 is controlled by a control device 48. While the glass substrate 1 is held by the holding hole of the carrier 45, the main surfaces 2 and 3 of the glass substrate 1 are polished simultaneously by the upper and lower polishing pads 43 and 44. During the polishing, a polishing slurry is supplied from an abrasive feeder 46. The abrasive feeder 46 is provided at one point in Fig. 9. However, there is no limitation to it. The position and the number thereof can be arbitrarily determined.

[0081] In the rough polishing step S60, it is preferable that the polishing liquid (polishing slurry) to be used contains cerium oxide, zirconium oxide, zirconium silicate, or the like as polishing abrasive particles. The concentration of cerium oxide in the polishing liquid, for example, is about 5% to 10%. The thickness of the allowance with respect to the main surfaces 2 and 3 of the glass substrate 1 to be polished, for example, is 10 μm to 30 μm . The waviness and roughness on the surfaces of the glass substrate 1 can be reduced to low levels by the rough polishing. The shapes of the inner circumferential edge surface and the outer circumferential edge surface of the glass substrate 1, for example, can be adjusted also by the rough polishing. The Ra of the surfaces of the glass substrate 1 after the rough polishing, for example, is about 3 to 10 $\text{\AA}$. As described above, the main surfaces 2 and 3 of the glass substrate 1 are roughly polished. After the rough polishing, the glass substrate 1 is washed with acid such as sulfuric acid or hydrofluoric acid.

[0082] Washing step S65

Again with reference to Fig. 6, the glass substrate 1 is washed with an acidic washing liquid after the rough polishing step S60. Such washing aims to remove, from the surfaces of the glass substrate 1, one of cerium oxide, zirconium oxide, and zirconium silicate used as a polishing slurry in the preceding rough polishing step S60.

[0083] Specifically, the glass substrate 1 after the rough polishing is detached

from the polishing pads used in the rough polishing step S60, and thereafter the surfaces of the glass substrate 1 are washed and etched, using a washing liquid containing sulfuric acid and/or hydrofluoric acid. The polishing slurry such as cerium oxide, zirconium oxide, or zirconium silicate adhering to the surfaces of the glass substrate 1 is appropriately removed by the washing liquid that is a strong acid such as sulfuric acid and/or hydrofluoric acid. Thereafter, the glass substrate 1 is washed with an acidic washing liquid.

[0084] The concentration of the washing liquid used in the washing step S65 is preferably about 1% to 30% in the case of sulfuric acid, and is preferably about 0.2% to 5% in the case of hydrofluoric acid, though it also depends on the chemical resistance of the glass substrate 1. The washing with such a washing liquid may be performed inside a washer in which an aqueous solution is retained while ultrasound is applied thereto. The ultrasound frequency used herein is preferably 78 kHz or more.

[0085] Chemical strengthening step S70

After the washing step S65, the glass substrate 1 is chemically strengthened. As a chemical strengthening solution, a mixed solution of potassium nitrate (60%) and sodium sulfate (40%), for example, can be used. The chemical strengthening solution is heated, for example, to 300°C to 400°C. The washed glass substrate 1 is preheated, for example, to 200°C to 300°C. The glass substrate 1 is immersed in the chemical strengthening solution, for example, for 3 to 4 hours.

[0086] The immersion is preferably performed in the state where a plurality of glass substrates 1 are accommodated in a holder so as to be held by their edge surfaces such that the entire main surfaces 2 and 3 of the glass substrate 1 are chemically strengthened. The immersion of the glass substrate 1 in the chemical strengthening solution causes the substitution of alkali metal ions (lithium ions and sodium ions) on the surface layers of the glass substrate 1 by chemically strengthening salts (sodium ions and potassium ions) having relatively large ionic radius in the chemical strengthening solution. This

allows compressive stress layers having a thickness, for example, of 50 μm to 200 μm to be formed on the surface layers of the glass substrate 1.

[0087] The surfaces of the glass substrate 1 are strengthened by the formation of the compressive stress layers, thereby allowing the glass substrate 1 to have a good impact resistance. The chemically strengthened glass substrate 1 is washed as appropriate. For example, the glass substrate 1 is washed with sulfuric acid, and thereafter is further washed with pure water, IPA (isopropyl alcohol), or the like.

[0088] Precision polishing step S80

After the chemical strengthening step S70, the glass substrate 1 is subjected to precision polishing. The precision polishing step S80 aims to finish the main surfaces of the glass substrate 1 to mirror surfaces. In the precision polishing step S80, precision polishing is performed on the glass substrate 1 using a double-side polishing machine (see Fig. 9), in the same manner as the aforementioned rough polishing step S60.

[0089] Between the precision polishing step S80 and the aforementioned rough polishing step S60, the polishing abrasive particles contained in the polishing liquid (slurry) to be used and the compositions of the polishing pads to be used are different. In the precision polishing step S80, the particle size of the polishing abrasive particles in the polishing liquid that is supplied onto the main surfaces 2 and 3 of the glass substrate 1 on which the compressive stress layers are formed is reduced and the hardness of the polishing pads is reduced as compared to the rough polishing step S60.

[0090] One example of the polishing pads to be used in the precision polishing step S80 is a soft foam resin polisher. One example of the polishing liquid to be used in the precision polishing step S80 is colloidal silica having a particle size finer than the cerium oxide abrasive particles used in the rough polishing step S60. The (primary) particle size of colloidal silica to be used in the precision polishing step S80 is preferably 15 nm to 80 nm. The precision polishing using colloidal silica increases the smoothness of the main surfaces 2 and 3 of the

glass substrate 1.

[0091] Scrubbing step S90

After the precision polishing step S80, the glass substrate 1 is scrubbed. Specifically, the glass substrate 1 after the precision polishing is detached from the polishing pads used in the precision polishing step S80, and thereafter the surfaces of the glass substrate 1 on which the compressive stress layers are formed are scrubbed using a scrubbing device while a washing liquid is supplied onto the surfaces of the glass substrate 1.

[0092] After the glass substrate 1 is detached from the polishing pads of the double-side polishing machine, the glass substrate 1 may be temporarily stored in water. The storage in water can reduce the amount of foreign matter such as polishing residue or loose abrasive particles adhering to the glass substrate 1 after the precision polishing, while preventing the surfaces of the glass substrate 1 from drying after the precision polishing. After the glass substrate 1 is stored in water for a predetermined time, the glass substrate 1 is set in the scrubbing device, and the glass substrate 1 is scrubbed.

[0093] For scrubbing, a washing liquid such as a detergent or pure water, for example, is used. The pH of the washing liquid to be used for scrubbing is preferably 9.0 or more and 12.2 or less. When it falls within this range, the ζ -potential can be easily adjusted, so that the scrubbing can be efficiently performed. As the scrubbing, both scrubbing with a detergent and scrubbing with pure water may be performed. The glass substrate 1 can be washed more appropriately by using a detergent and pure water. The glass substrate 1 may be further rinsed with pure water between the scrubbing with a detergent and the scrubbing with pure water.

[0094] After the scrubbing, the glass substrate 1 may be further ultrasonically washed. After the scrubbing with a detergent and pure water, ultrasonic washing with a chemical solution such as a sulfuric acid aqueous solution, ultrasonic washing with pure water, ultrasonic washing with a detergent, ultrasonic washing with IPA, and/or steam drying with IPA, for example, may

be further performed.

[0095] The method S100 for manufacturing the glass substrate 1 according to this embodiment is configured as above. The glass substrate 1 of this embodiment shown in Fig. 2 and Fig. 3 can be obtained by using the method S100 for manufacturing the glass substrate 1.

[0096] Magnetic thin film forming step S200

A magnetic recording layer is formed on the main surfaces 2 and 3 of the glass substrate 1 (or one of the main surfaces 2 and 3) after the completion of the scrubbing. The magnetic recording layer is formed, for example, by sequentially forming an adhesion layer composed of Cr alloy, a soft magnetic layer composed of CoFeZr alloy, an orientation control base layer composed of Ru, a vertical magnetic recording layer composed of CoCrPt alloy, a C-based protective layer, and an F-based lubricant layer. By forming the magnetic recording layer, the information recording medium 10 shown in Fig. 4 and Fig. 5 can be obtained.

[0097] Examples

Next, examples of the method for manufacturing the glass substrate 1 will be hereinafter described together with comparative examples with reference to Fig. 10. Fig. 10 is a table showing the evaluation results of Examples 1 to 4 and Comparative Examples 1 and 2.

[0098] In Examples 1 to 4 and Comparative Example 2, a main surface of the glass substrate 1 was ground (surface roughened) in the blasting step S30 using the aforementioned particles (abrasive particles). Alumina particles were used as the particles (abrasive particles). Alumina particles having a size of 110 μm and the nozzle 110 having an opening diameter of 6.5 mm were used. The glass substrate 1 had a Vickers hardness of 610 kg/mm².

[0099] For controlling the roughness, the spraying pressure and the spraying time (grinding allowance) were varied. After they were varied so as to achieve Ra₁ and Ra₂ as described in Fig. 10, the subsequent steps S30 to S90 were performed. Ra₁ and Ra₂ of the glass substrate were controlled by the size of the

abrasive particles and the allowance (grinding thickness). In Comparative Example 1, the subsequent steps S30 to S90 were performed without performing the blasting step S30.

[0100] To evaluate the examples and the comparative examples, the number of defects was analyzed. The number of defects was evaluated using an OSA (Optical Surface Analyzer). As the OSA, Candela 6300 manufactured by KLA-Tencor corporation was used. In the evaluation, the cases where the number of defects was 20 or less were evaluated to be acceptable, and the cases where the number of defects was 21 or more were evaluated to be unacceptable.

10 [0101] Example 1

The blasting step S30 was performed in Example 1 under processing conditions of an abrasive particle size of 67 μm and an allowance (grinding thickness) of 5 μm . As a result, Ra_1 was 1 μm , Ra_2 was 0.1 μm , the number of defects was 15, and evaluation was "acceptable".

15 [0102] Example 2

The blasting step S30 was performed in Example 2 under processing conditions of an abrasive particle size of 67 μm and an allowance (grinding thickness) of 10 μm . As a result, Ra_1 was 2 μm , Ra_2 was 0.2 μm , the number of defects was 5, and evaluation was "acceptable".

20 [0103] Example 3

The blasting step S30 was performed in Example 3 under processing conditions of an abrasive particle size of 90 μm and an allowance (grinding thickness) of 12 μm . As a result, Ra_1 was 2 μm , Ra_2 was 0.3 μm , the number of defects was 5, and evaluation was "acceptable".

25 [0104] Example 4

The blasting step S30 was performed in Example 4 under processing conditions of an abrasive particle size of 110 μm and an allowance (grinding thickness) of 12 μm . As a result, Ra_1 was 5 μm , Ra_2 was 1 μm , the number of defects was 13, and evaluation was "acceptable".

30 [0105] Comparative Example 1

In Comparative Example 1, the blasting step S30 was not performed. As a result, Ra_1 was 2 μm , Ra_2 was 0.01 μm , the number of defects was 23, and evaluation was "unacceptable". The number of defects is considered to have increased because the value of Ra_2 was smaller than those in Examples 1 to 3, and therefore cracks easily occurred in the subsequent steps.

[0106] Comparative Example 2

The blasting step S30 was performed in Comparative Example 2 under processing conditions of an abrasive grain size of 150 μm and an allowance (grinding thickness) of 30 μm . As a result, Ra_1 was 6 μm , Ra_2 was 1.5 μm , the number of defects was 32, and evaluation was "unacceptable". The number of defects is considered to have increased because the blasting step was excessively performed as compared to Examples 1 to 3, and thus cracks occurred.

[0107] It was confirmed from the aforementioned results of the examples that the occurrence of cracks can be effectively suppressed when the main surfaces 2 and 3 are ground in the blasting step S30 by spraying the particles 200g onto the main surfaces 2 and 3 such that the main surfaces 2 and 3 have an arithmetic average roughness Ra_1 maintained within the range of 1 μm to 5 μm and further an arithmetic average roughness Ra_2 , when a cut-off value is set to 2.5 μm to 80 μm , within the range of 0.1 μm to 1.0 μm .

[0108] In the method for manufacturing a glass substrate for an information recording medium according to this embodiment, the main surfaces are ground in a blasting step that is a first grinding step by spraying particles onto the main surfaces such that the main surfaces have an arithmetic average roughness Ra_1 maintained within the range of 1 μm to 5 μm and further an arithmetic average roughness Ra_2 , when a cut-off value is set to 2.5 μm to 80 μm , within the range of 0.1 μm to 1.0 μm , as described above, thereby allowing an appropriate surface roughening step to be performed before a grinding step, even in the case of using a glass substrate having high hardness.

[0109] While embodiments and examples based on the present invention have been described above, the embodiments and examples disclosed herein are to be

understood as being exemplary in all respects and in no way limiting. The scope of the present invention is defined by the scope of the appended claims, and all changes that fall within the same essential spirit as the scope of the claims are intended to be included therein.

5 [List of Reference Numerals]

[0110]	1	Glass substrate (glass substrate for an information recording medium)
	2, 3	Main surface
	4	Inner circumferential edge surface
10	5, 15	Hole
	6	Outer circumferential edge surface
	7, 8	Chamfered portion
	10	Information recording medium
	12	Compressive stress layer
15	14	Magnetic recording layer
	20	Housing
	21	Head slider
	22	Suspension
	23	Arm
20	24	Perpendicular axis
	25	Voice coil
	26	Voice coil motor
	27	Clamping member
	28	Fixing screw
25	30	Information recording device
	40	Double-side polishing machine
	41	Lower surface plate
	42	Upper surface plate
	43, 44	Polishing pad
30	45	Carrier

	46	Abrasive feeder
	48	Control device
	100	Blasting device
	110	Nozzle
5	120	Support base
	200g	Particles (Abrasive particles)

CLAIMS

1. A method for manufacturing a glass substrate for an information recording medium, comprising:

5 a first grinding step of grinding a main surface of a glass substrate obtained using a direct pressing process by spraying a plurality of particles onto the main surface of the glass substrate through a nozzle; and

a second grinding step of grinding the main surface of the glass substrate after the first grinding step with fixed abrasive particles mainly composed of diamond particles having an average particle size of 2 μm to 10 μm ,
10 wherein the first grinding step includes

a step of grinding the main surface by spraying the particles onto the main surface such that the main surface has an arithmetic average roughness Ra_1 maintained within the range of 1 μm to 5 μm and further an arithmetic average roughness Ra_2 , when a cut-off value is set to 2.5 μm to 80 μm ,
15 within the range of 0.1 μm to 1.0 μm .

2. The method for manufacturing a glass substrate for an information recording medium according to claim 1,

20 wherein the main surface has a Vickers hardness of 610 kg/mm^2 or more.

3. The method for manufacturing a glass substrate for an information recording medium according to claim 1 or 2,

25 wherein the particles have a maximum particle size of 50 μm to 150 μm .

4. The method for manufacturing a glass substrate for an information recording medium according to any one of claims 1 to 3,

wherein the particles are sprayed at a pressure of 0.1 MPa to 1 MPa.